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ABSTRACT

This report describes evaluations of two courses which were conducted, primarily through participant observation, in 1981. A general introduction looks at simulation in computer assisted learning (CAL) and at use of simulation CAL in the Open University science faculty. The first study discussed was based largely on a tutor's observations of student interaction with three genetics simulations during a week-long, summer school biology course. The simulations were EV299, a simple model of natural selection; OPERON, a more difficult program; and LNKOVR, which allows students to genetically map an "electronic organism." Evaluation of the second course focused on the CAL experiences of students during a summer school quantum mechanics course that involved use of two simulations: WELLS, which is used to find the eigenfunctions and eigenvalues of particles in potential wells by numerical integration of Schrodinger's equation, and MEASURE2, which allows students to describe what happens to eigenfunctions when various types of measurement are performed on a quantum harmonic oscillator. Study conclusions, a summary discussion, and six recommendations regarding CAL simulation in distance learning are included. (LMM)

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Computer Assisted Learning Research Group

EVALUATION STUDY ON SIMULATION CAL IN THE SCIENCE FACULTY OF THE OPEN UNIVERSITY

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CAL Research Group Technical Report No. 15

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PREFACE

In this Technical Report we present the results of an evaluation exercise on the use of simulation CAL in the Science Faculty of The Open University during 1980. Based upon our findings, we also recommend some guidelines on the future use of this type of CAL in distance learning.

Two points require immediate emphasis.

The first is that this study is based upon two, named Open University courses. In one case we have had to point out glaring deficiencies in the organization of the CAL element of the course. This should not be taken to indicate criticism by us of the course team concerned and certainly not of the part-time tutors. There are few courses which use simulation CAL, mistakes are inevitable until sufficient experience has been acquired and we can all now benefit from that experience. Also, frequent reference is made to difficulties encountered in 'logging-in' to programs on the Academic Computing Services' computer system. Again, these should not be interpreted as critism by us of ACS, which in general provides the University with an excellent service. Difficulties arise for all sorts of reasons. The point is that we should all endeavour to minimise them and their adverse impact on students' learning.

The second point is that this study is far from being an extensive, objective evaluation. Information was largely collected by participant observation by the authors (in the role of tutor, student or onlooker). It is thus quite subjective, and maybe rather unrepresentative in that the observations were made during a few, quite short periods of time. Nevertheless, we believe that it does allow us to make recommendations which, if taken note of, should result in more successful use of simulation CAL in the future. We believe that we have conducted an 'illuminative' evaluation.

In order to be able to retain the use of the word "I" and all that that implies when relating events, we have identified with our initials those sections for which we are individually responsible (Sections 2, 3 and 4). We are jointly responsible for this Preface and for Sections 1, 5 and 6.

P.J.M.

E.S.

E.L.W.

June 1981

1.0 INTRODUCTION

1.1 What Is Simulation CAL?

CAL clearly involves the use of electronic computers in teaching and/or learning. However, the term covers a wide range of activities at many different academic levels. Since it means different things to different people, depending on their own experience of it or on what they have heard, it is as well to start this Report by clarifying what we mean, and what we do not mean, by simulation CAL. This is perhaps best done by describing the three main categories of CAL currently in use in the Science Faculty of The Open University. These categories are:

(1) the use of computers for data analysis in the teaching laboratory,

(2) tutorial CAL,

(3) simulation CAL.

The first category, the use of computers for data analysis, is the most obvious application and it has been used as a considerable aid in chemistry practicals at S101 Summer Schools. Its main advantages are the saving of time and the possibility of students analysing for themselves more complex experimental data than would otherwise be possible.

In tutorial CAL the computer is programmed to attempt, generally at an educationally routine level and for a short time, to take over a role which would otherwise be played by a tutor. Most tutorial CAL programs are written in author languages (as opposed to programming languages such as BASIC, PASCAL or FORTRAN) and three such languages are in use in the Science Faculty. STAF programs are interactive and permit students to respond to questions and prompts printed at the computer terminal by typing in ordinary English. The Chemistry Discipline have used several STAF programs (known as CALCHEM) for some years and the language is now finding favour elsewhere within the Faculty. CICERO tutorials can be provided in an interactive form or as a postal alternative. They also differ from STAF tutorials in that students respond to multiple choice questions. The language is therefore suitable for topics too 'open-ended' for STAF (where answers have to be anticipated in advance by the author). In Science, CICERO was used by the original BBB course (SDT286) and it has also been adopted by the replacement course (SD286). The third author language in use by the Science Faculty is MERLIN. MERLIN is an interactive system based on multiple choice questions. Its unique feature is that some of the tutorials occur on 'supervised' nights when a tutor monitors several students' interaction with the computer. Telephone conversations between any of the students and the tutor can be initiated by either in order to clear up areas of misunderstanding. So far MERLIN has been used by only one course, Images and

Information (ST291).

Simulation CAL is quite different from either data analysis or tutorial CAL, although any two or all three might well be integrated to great educational effect. In simulation CAL the computer is not simply a 'number-cruncher', nor does it take over the tutor's role in any way. Instead it takes the place of a laboratory or of a field situation and students are invited to carry out 'experiments' which would otherwise be impossible, or at least very difficult, due to expense, time, danger, ethics, etc. With good simulations it is usually possible to allow students much greater freedom in the planning of their experiments than would ever be possible with 'real' experiments. Considerably enhanced understanding of how science is 'done', and how data can be analysed and interpreted, can result.

Generally, simulations present students with a number of parameters or variables (e.g. population size, temperature, dimensions of a potential well) for which they have to input values. When all the parameters of the model have been set, the program runs and output, which requires interpretation by the student, appears. Usually the output is in the form of data, either numbers <u>per se</u> or as a plot of some kind. As a result of interpreting this output, students may well want to re-run the program, having modified the values for one or more of the variables.

Good simulations have some definite goal for which the students are aiming. Under these circumstances, the use of simulations can be very motivating and even fun --- more like a game with educational spin-offs than work. Usually the goal is not explicit in the program itself, but set by the tutor, by the accompanying documentation or, occasionally, by the students themselves. Prior knowledge of the topic is often assumed, for instance that the relevant Open University Units have been studied. The point is that many simulations will be educationally effective only if the students and, where relevant, their tutors are adequately prepared for the task in hand. It is also true to say that students benefit immensely from a well structured and informed de-briefing session after their interaction with the simulation.

1.2 Simulation Cal In The Science Faculty

The Science Faculty, and indeed The Open University as a whole, employs very little CAL in its teaching. Moreover, most of the CAL it does use is tutorial CAL written in one or other of the three author languages. There was not therefore very much simulation CAL to evaluate in 1980. In fact, effectively, only two courses used it --- Genetics (S299) and Quantum Mechanics (SM351). This is perhaps surprising since simulations covering a range of relevant topics have been readily available for some time from such sources as the Chelsea Science Simulation Project (CSSP),

the Schools Council Computers in the Curriculum (CC) Project, Hertfordshire's Advisory Centre for Computer Based Education and the Computers in the Undergraduate Science Curriculum (CUSC) Project, and in fact many of these simulations have been stored on our own computer system. While it is true that most of the simulations were written primarily for the secondary education sector, many would be suitable for Open University use with little or no modification provided that supporting documentation, appropriate to the needs of our students, was written. Of the simulations mentioned in this Report two originated from CSSP and two from CUSC. Another striking fact is that The Open University has hardly used computer simulations in distance learning at all. Most simulation CAL is used at Summer School when we ourselves are 'simulating' conventional universities. The rest tends to be used by students at Study Centres, but in the presence of, and guided by, their tutors. However, there will come a time in the near future when we shall be able to offer CAL, including simulation CAL, for unsupervised students to use in their own homes.

In 1980, as in previous years, the Genetics course made three computer simulations available to its students. Take-up outside Summer School was negligible and, where it did occur, was entirely due to the enthusiasm of particular part-time tutors. Even at Summer School CAL was relegated to time-tabled, but voluntary, 'enrichment' afternoons. Its

use was not subject to assessment, although the simulations related directly to topics within the course which were themselves assessed in the usual ways. The Quantum Mechanics course had also been using its two simulations at Summer School for a number of years. However, in this case the computing sessions were compulsory and timetabled into the week just as were more recognisable physics experiments. These differences between the two courses were further reflected in the documentation supplied to both students and tutors by the course teams and by the general level of enthusiasm for CAL and expertise in its use manifest in the tutors.

1.3 Participant Observation

Since the observations reported in the succeeding sections, and thus our final recommendations for the future use of simulation CAL, are based heavily on 'participant observation', a few words about it as an evaluation technique are appropriate.

With any type of innovatory (or even 'conventional') education, controlled experimentation is impossible and , if attempted, is likely to produce quite spurious results. It is meaningless to compare, say, a practical class with a lecture and it is equally meaningless to compare the practical class with a CAL simulation. One can never get truely matched groups (except perhaps by using

unrealistically large numbers of students). Matched teaching is also unattainable whenever a human teacher is involved and pre- and post-tests on the same group seldom tell one anything about what went on in between.

One is normally left with no option but to observe --- subjectively, but intelligently --- and this is what we have tried to do. In the case of S299, two of the authors attended the Summer School on different weeks --- one (E.S.) joined the students, and the other (P.J.M.) was there as a tutor. In the case of SM351, the third author (E.L.W.) 'sat-in' on two computing sessions as neither a student nor a tutor. Obviously the observer-as-tutor influenced how sessions actually went, but we are convinced that the observer-as-student and the observer-as-onlooker had no significant influence on the success or otherwise of the sessions they attended. As an illustration of this, E.S. wore a staff badge at the S299 Summer School and did not introduce herself to either the students or the tutors, yet her presence was readily accepted by the students and the tutors seemed to treat her as if she was an S299 student. In any case, our object was not to make a detailed sociological analysis of the sessions we attended, but to be in a position to make recommendations about how such sessions should be improved. We believe that we have achieved our objective.

2.0 S299 SUMMER SCHOOL: TUTORS' VIEW (P.J.M.)

2.1 Introduction

This report is based largely on observations made during one week of the S299 Genetics part of the BIOL999 Summer School, during which the author was a tutor on Block 9 (Quantitative Genetics). Comments are therefore not made from an unbiased position. Moreover, the author (a) is specifically employed within the Science Faculty to promote the use of CAL, (b) has had a lot of experience in using computer simulations with biology students, and (c) was involved in the writing of two of the three simulations referred to below.

Three computer simulations in the area of genetics and evolution (EV299, OPERON and LNKOVR) were made available to S299 students at Study Centres and at Summer School. The Summer School use is mainly on 'enrichment' afternoons (Monday and Wednesday) when laboratory exercises are not scheduled. At the Summer School, one 'hardcopy' terminal was provided in the Block 9 laboratory and four terminals (some VDUs and some 'hardcopy') in the Chemistry Building some distance away. In addition to the Block 9 laboratory terminal, three of the terminals in Chemistry were available to biologists on Monday afternoons and one on Wednesday afternoons. No arrangements had been made with the chemistry tutors regarding the allocation of VDU and 'hardcopy' terminals on Wednesday afternoons, when both groups would converge on the same room.

In 1979 a type-written booklet, with information on procedures for using the computer system and also with brief descriptions of the programs, was mailed to students and part-time tutors. Some of the more glaring errors in the booklet were corrected for 1980, but basically it was unaltered. However, it was not mailed to students in 1980, but instead was made available for reference at Summer School. Students were told that copies would be supplied from Walton Hall on request. For an unknown reason the booklet did not appear initially at the Summer School. Large numbers of an entirely outdated printed booklet (which referred, for instance, to different programs) were found somewhere and issued to students that week. When I discovered this situation the current booklet was substituted and arrangements were made for the disposal of the older material.

At Summer School, S299 tutors were required to run one of the two alternative 'enrichment' activities on one of the two afternoons. In this particular week the Course Director simply asked for volunteers to supervise the CAL 'enrichment'. Because of my involvement with CAL I opted to run it on both afternoons. There were only two tutors, together with two demonstrators (who are not required to involve themselves with the 'enrichments', but usually do), employed in this week. There is no reason to suppose that a person appointed to tutor genetics at Summer School will have any interest in, or knowledge of, CAL. They are

provided with no training, nor are they supplied with any information additional to that in the booklet. This causes several problems. Firstly, a tutor must know a lot about the systems modelled, the assumptions made, etc in order to use the programs effectively. Secondly, no tutor can expect to be successful in using computer simulations with students having had no experience in, nor guidance on, the relatively novel educational approaches entailed in simulation CAL. There is also the possibility that tutors might feel ill-at-ease with the technology.

2.2 Observations

Four terminals were available on the Monday and only two on the wednesday. Because it was possible for several groups of students to use LNKOVR with the single terminal in the Block 9 laboratory I decided to deal with this program on the Wednesday. The other two programs were introduced on the Monday. It would have been quite impossible to deal with all three programs, except in the most superficial fashion, on a single afternoon. fashion, on a single afternoon.

Eight students attended on the Monday and seven on the Wednesday. Two students came to both sessions. Two of the Wednesday students were attending BIOL999 Summer School, but were not studying S299.

On both afternoons I ran through the procedure for 'logging-in' to the computer, covering the method normally employed at Study Centres and that in use at the Summer School (auto-dialling). 'Logging-in' was quite new to most of the students, but of those who had previously used a terminal, all but one seemed to appreciate the re-capitulation. The one exception was a very self-confident student who, having taken several maths courses, seemed intent on demonstrating how clever she was.

Monday

After 'logging-in' had been dealt with we used EV299. This program is a simple model of natural selection and, at first sight, does nothing but produce uninspiring columns of figures. In fact, careful preparation is required to get students into a suitable frame of thinking before they can make good use of the program. This was particularly true this week because some of the students had not yet studied the relevant parts of the course. In the limited time available, I mostly failed in this task. With the inadequate guidance in the booklet, I suspect that the exercise would degenerate into a game (without educational 'spin-offs') in the hands of some tutors.

The program OPERON was much more successful. It dealt with a difficult and relevant topic which had already been met in the course. Several students continued to argue about its output for the rest of the week and sought advice from the

Block 8 (Microbial Genetics) tutor on certain points. However, other students clearly preferred something less challenging and drifted into a rather aimless use of LNKOVR (on the basis that they could not attend on the Wednesday) or sought advice on the next TMA, etc.

I went to the Chemistry Building with six of the students, leaving the other two working in the Block 9 laboratory. It was noticeable how much more slowly the smaller, isolated group worked. It was also striking how much more in demand were the 'hardcopy', compared to the VDU, terminals.

Wednesday

On the Wednesday afternoon, after a brief introduction, three pairs of students and one individual set about the task of using LNKOVR to genetically map an 'electronic' organism. Two students working together (neither of whom were studying S299) were quite clearly lost, but nevertheless gamefully tried to follow a 'recipe' and apparently enjoyed themselves. The others also enjoyed themselves and made very good progress. When the maps were ready we compared them with each other and also with the 'cytological' map. This latter is not available from the program, nor was it in the booklet. Most tutors would therefore not be in a position to make this comparison, which highlights some important genetic phenomena. Afterwards the students opted to use OPERON, some for the second time.

2.3 Conclusions

It is clear that:

(1) Advice on the use of computer simulations with classes should be available to tutors.

(2) Tutors need much better information about the models and they certainly require any 'answers'.

(3) Information about the programs needs to be available to students at the approriate time and in an attractive format.

(4) If they are to be perceived as being useful, simulations must be seen to be relevant.

(5) Graded exercises with a clear purpose would minimise the chance of students aimlessly 'playing' with the programs.

(6) Students want to take away with them 'hardcopy' of their interaction with the computer.

3.0 S299 SUMMER SCHOOL: STUDENTS' VIEW (E.S.)

3.1 Introduction

During one week I visited the S299 Genetics part of the BIOL999 Summer School and attended, as a student, one of the computer sessions scheduled on the programme. This is an account of the observations I made and the conclusions I drew from them.

3.2 Observations

Monday 2pm

Twelve students and I arrive in the Block 9 Laboratory where a computer simulation 'enrichment' session has been scheduled. The only information provided to students beforehand was the following sentence in the Introduction and Guide to the Summer School:

"There will be computer-based exercises for S299 students using SCS [now ACS] terminals"

There is only one terminal available in the laboratory.

The tutor arrives and walks straight to the terminal saying, "Let's see if we can get this thing going." One lady student asks, "Why does everything take twice as long with a computer?" The tutor tries for 5 minutes to get some response from the terminal, but with no success. He 'phones for advice, but still having no success, he declares his intention of going through some printout he has from a previous run of the program. By this time twenty students have arrived and we are all crowded around the one printout.

The tutor describes LNKOVR as a program which deals with a set of genes 'ACH', and says that using it we can find out the order and linkage distances between the genes. He describes it as a "good exercise about whether you

understand about three point test crosses."

A student asks what does '+++' stand for. The tutor replies that it stands for 'wild type', but that the student shouldn't be thrown by the different notation from the Units.

He then uses a blackboard to analyse the following data from the printout:

ACH	24
+++	24
+CH	3
A++	2
++H	3
AC+	2
+C+	15
A+H	27

He asks, "How should we set about sorting out the order of the genes?" And then goes on to say that the least frequent classes (i.e. A++ and AC+) should be the double crossovers. However, the double crossovers obtained from ACH and +++ are A+H and +C+. Therefore, the two smallest frequencies have been produced by random assortment. Thus there must be some sampling error which resulted in the smallest frequencies not really being the double crossovers. He calculates linkage distances as follows:

Single crossovers 1 A++ 2

+HC 3

	2	AH+	27
		++C	15
Double crossovers	1 2	A+C	3
		+H+	3

To calculate distances 1 $\frac{2+3+2+3}{100}$ = 10 units

2 $\frac{27+15+2+3}{100}$ = 47 units

So the solution to the problem is:

A---(10)---H----------(47)----------C

He then says, "Now, we'll set the machine up and try another two genes or try another example of the same one to see if it works out the same." Another tutor arrives. He is told by the first that, "We're having awful problems here!" The second tutor replies, "Shall we try the bead game instead?" All the students laugh. The bead game isn't tried.

2.15

First tutor: "If this works we'll get millions of years of gene frequencies available to us. We'll try and get it to work, otherwise there are some excellent shops in Nottingham I can recommend to you." Other tutor: "Shall we get the tiddley winks out for the selection experiment?" Conversation among students: "I've never understood how this works ... Why that was ... It's something to do with the curve." The tutor has a telephone conversation with the

computer advisor.

The tutor succeeds in 'logging-in'. "Did you all see how we did that?" Three students look at each other in disbelief. He says, "Some people are bored with this before they start. Others get hooked and spend all week trying different combinations."

The computer now prints READY. The tutor looks at the instruction sheet, "Must check that they've left in the program from last year." He spells LNKOVR incorrectly.

"Let's try A [RETURN]
C [RETURN]
H [RETURN]
.. and we get these random numbers."

A student asks, "Where does the computer get its numbers from .. Is it doing its own experiment or using the results from someone else?" No answer.

The tutor asks, "Who wants to take these results to do three point tests? Shall we get another set of results to use?" Students, in twos and threes, are given sets of results to work on.

A student suggests PRT. Another student asks,"Can we choose any letter in the alphabet?" One student says, "I'm not sure what's going on here ... do we have to feedback the results of our experiment as in a CMA or what?"

A run is produced which has fewer than eight classes. The tutor says, "That's interesting. Maybe someone died in the middle of this experiment ... Does anyone want to study this one?" A students asks, "Is it hard?" The tutor replies, "Well, it'll take some thinking about." "No. I'll have a normal one please." Another student remarks, "It's clever to have a machine which will put in random errors like people dying out."

A student asks, "Will we be able to put results all together at the end of the afternoon?" "Yes." The tutor says, "Now go and work out your results. Don't forget that bacterial crosses are circular!"

Students now take turns at typing in three letters and getting printouts. "Types fast doesn't it" One experienced lady stands by the terminal and helps out. "You've forgotten the RETURN key between genes." "It's nicer than the one at my Study Centre."

A students asks, "How do you know you're right." Tutor: "If the arithmetic is right it'll be alright." The tutor goes round one or two groups talking to students.

2.55

Three latecomers arrive. Their experiment didn't work. The tutor asks them to pick three letters. They ask, "How do you get it to do all this in the first place?" He talks them through 'logging-in' and then repeats his blackboard example.

At this stage all the students are involved in doing sums. General atmosphere is one of laughter and hilarity. It all seems to be going quite well.

3.15

The tutor appears with copies of the white computer instruction sheets, "It's only what you were just doing." A student asks, "Is the computer available at any time outside the practicals?" "Yes, until 9.15."

Students are getting annoyed that one lady hogs the terminal and has six goes with different letters. "OK, she's made a discovery. But the rest of us would like to, too."

One students asks it they are going to use other programs. The tutor replies that "they're more demonstrations and we'll probably try them on Wednesday afternoon."

Discussing a problem to do with genetic drift, the tutor says, "Selection would be very nice if it had a switch on which would tell you how it really works. It's more like real life, but that doesn't really get you anywhere." Students laugh. Then one asks, "Does anybody know what the correct sequence is?" A student asks about the third program on the instruction sheet. The tutor replies, "It's an old one I think."

All students are still present.

3.30

Two groups think they've sorted out the order, but not the distances.

An M352 student arrives to use the terminal. The terminals in the Chemistry Building are switched off. He receives instructions about how to switch them on.

The second tutor asks students whether they had received the blue Computer Handbook (waves a copy aloft). None of them had.

3.45

Teatime. I visit the Chemistry laboratory. There are no terminal supervisors, no documentation for biology programs, no information about how to 'log-in'. Only one terminal is operational.

4.00

Return to Biology laboratory. The tutor is still at tea. Three students don't return from tea. One more student leaves saying, "It's just repetitive." Another says, "The tutor hasn't come back --- maybe he's got a lecture."

The students continue for some time, getting printouts and doing calculations.

4.30

Six more people leave. One student asks, "Is there anything around which tells us what the answer is?" On discovering that there isn't: "That's great!" The student leaves in disgust.

4.35

Seven more people leave. The Course Director appears. He is surrounded by students. Does he know what the correct answer is? He doesn't, so leaves. He sends along another genetics tutor who enquires what has happened. He is told that the original tutor has gone. He asks when the session is due to end and decides that there is no point in looking

for the other tutor.

A large group leaves to go to the film, "for light relief'. Two groups of students think that they have solved the problem.

Three students are left in the laboratory.

A BBB student arrives and 'logs-out' prior to starting a CAL tutorial. One student comes back and insists on restarting LNKOVR. She has a poor view of the tutor. "Probably the program knows the answer if only you know how to get it out."

3.3 Conclusions

My assessment is that:

1. None of the students were scared of generating numbers with the program.
2. None of them had any idea where the numbers were coming from.
3. They had lots of practice in doing calculations.
4. None of them had a model of what was going on (they did not get notes to suggest that that's what they should do until well into the afternoon).
6. They got cross about not having an end point.
7. They were eager to do more.

In summary:

Organisationally the afternoon was a disaster. It consisted of:

1. Inadequate documentation for students.
2. Tutors who were ignorant of the purpose of working with the computer.
3. Students who got much less out of this session than they should have done.

4.0 SM351 SUMMER SCHOOL (E.L.W.)

4.1 Introduction

Approximately 25 students attended each of the 3 week-long Summer Schools for the Quantum Mechanics course SM351. During the week in which I attended the School as observer the students were divided into two groups and used the computing facilities on alternate evenings. Each group attended two computing sessions, with an evening engaged on other activities in between. The sessions were compulsory and each lasted for 3 1/2 hours from 4.30 to 9.30 pm with a 1 1/2 hour break for dinner.

Four terminals were available, located in two seminar rooms near the physics laboratories. The terminals could be linked to the ACS computers by telephone. Instructions were posted on the walls by each terminal giving the dial-up and log-in procedures. Normally the terminals were linked with the ACS computer in London, although it was possible to connect with the Newcastle or Milton Keynes computers if

necessary.

Two programs were available for use by SM351 students, namely WELLS and MEASURE2. WELLS was used to find the eigenfunctions and eigenvalues of particles in potential wells by numerical integration of Schrodinger's equation. The calculations can be done by hand and a wave function representing the solution plotted out manually. However, the WELLS program does all the lengthy calculations and plots out the wavefunction appropriate to the data input by students. The MEASURE2 program is an analogue of a quantum mechanical system and allows measurements of position and momentum on a simple harmonic oscillator to be simulated. It enables the student to describe what happens to eigenfunctions when various types of measurement are performed on a quantum harmonic oscillator.

Both programs relate directly to Unit texts. By the time they came to Summer School, the students had already studied the material relating to WELLS, but had yet to study the Units relating to MEASURE2.

The computing sessions were conducted in a tutorial mode and relied heavily on the tutors' lead. During both sessions 15-20 minutes were spent on the content of the programs before students touched the terminals and the tutor was continuously available to sort out problems and help in interpreting the data.

Tutor Notes gave the tutor general guidelines on how to conduct the sessions and the Summer School booklet gave instructions to the students on running the programs.

4.2 Observations

The WELLS program was used by ten students out of a group of twelve. The tutor was very experienced in running these computing sessions and had developed techniques of her own to improve the value of the sessions. During the initial 15 minutes of the session, the tutor described the thecry behind the exercises which the students were about to do and then spent a further 15 minutes on the program itself.

Of the ten students present, only two were unfamiliar with the use of computer terminals.

The students spent the next 20 minutes of the session finding the eigenfunctions and eigenvalues of potential wells by numerical integration of Schrodinger's equation using hand calculators.

The students then formed into groups of 2 or 3 and proceeded to dial-up and log-in to the computer. Three out of the four groups encountered some difficulty with 'logging-in' mainly due to technical problems with the London computer. However, once the program was running, everything proceeded smoothly. The students studied square wells and harmonic

oscillators and were required to input the dimensions of height and width of each. They were then asked for the parity of the eigenfunctions they were looking for and finally they had to specify the energy. The computer then plotted out the whole, or a section, of the wavefunction representing the solution to Schrodinger's equation for the input values. Only when the correct energy eigenvalue was selected did the plot appear in the correct form, with the wave function approaching the x-axis asymptotically. The students were expected to input values for the energy until the correct wave-function was plotted. They then tried a new energy and found its solution. The program gave the solution if students were not able to get it for themselves. After obtaining two or three correct energy eigenvalues it was possible to work out the series which these energies follow, and students who did this found it very rewarding. When each energy value was correctly chosen, the program printed the message CONGRATULATIONS!

After the dinner break, only two students failed to return to continue with the session. Most of the analysis of the printouts was done whilst working at the terminals, so students tended to remain there until they had tried sufficient energy values for both the square well and the harmonic oscillator.

During the computing session the following evening, the MEASURE2 program was used by the other group of students (who had used WELLS on the first computing session, two evenings before). The tutor spent 40 minutes explaining this program, which modelled an oscillating quantum mechanical system. It enabled students to perform simultaneous measurements and observe the effects the measurements had on the system. The students had not yet studied the Unit to which this material relates.

In this session there were many problems 'dialing-up' and 'logging-in' to the computer.

MEASURE2 was a more complicated program than WELLS and so the pattern of use was rather different. Students tended to do a few runs and then leave the terminal to analyse their printouts. It was not as versatile as WELLS, where additional modes of use were suggested by the tutor. Students did not seem to get as much out of this program as they did from WELLS. After the dinner break, eight of the ten returned.

4.3 Conclusions

It was very obvious from my observations of the two computing sessions, that the tutor played a vital role in conducting the sessions. The sessions took the form of tutorials, with the computer acting as a tutorial aid,

rather than filling a direct teaching role. The tutor was able to make suggestions for additional use of the programs, particularly WELLS, which were not mentioned in the Summer School booklet and which the students found interesting. When the booklet is re-written some of these alternatives could be included, along with suggested orders of magnitude for the figures to be input to the computer. The students did not have the experience to experiment on their own with a large number of variables. The computer plots need a lot of interpretation as there are subtle features which require the tutor's guidance.

Comments from students indicated that they enjoyed the programs and welcomed the chance to use a terminal for several hours at a time, rather than the limited 30-40 minutes they usually get at the Study Centres.

Students should be encouraged to keep a record of the values they input since the printouts get very long and it is difficult to remember what has already been tried. A blank table in the Summer School booklet would encourage this.

The 'dial-up' and 'log-in' procedures are made more complicated than they need be by the plethora of intructions available in the Summer School booklet, on the wall of the computer rooms, on loose sheets by the terminals, etc, all of which give slightly different instructions! Sheets should be written <u>at the site</u>, after logging-in has been

acheived by the terminal supervisor, and then pasted to the wall. This should eliminate this particular problem.

In conclusion, the SM351 Summer School makes good use of its computing facilities. All the students bar one (a 'bored' computer programmer!) echoed this. However, successful use of the programs is heavily dependent on input by the tutor and, as I was present at only one week's computing sessions with just one tutor, I cannot say if they are always as successful. This Summer School has been running for six years and during this period attendance at the computing sessions has increased, due, I think, to increasing tutor involvement over the years.

5.0 DISCUSSION

Several things are immediately apparent from our observations. There is no evidence that the simulations themselves were in any way less than adequate, and this should not be surprising since they have been extensively tested. However, their successful use depended crucially on the tutors.

The SM351 tutor was obviously doing an excellent job and was able to greatly supplement the documentation provided by the course team. It would be sensible if that course team took note of the tutors' good ideas so that first-rate documentation can be supplied to new tutors or directly to

students if the simulations are ever to be used, for instance, by students using computer terminals or microcomputers in their own homes.

Equally clearly, some of the S299 tutors were unable to provide an adequate service for their students. Yet these tutors were very good indeed on other aspects of the Summer School --- running practicals, giving tutorials, etc. The reason why they performed so poorly when it came to CAL was that they did not know what to do. They did not know what to do because they were not told what to do by the course team --- who themselves may not have known what to do (in which case they should not have put CAL on the Summer School programme) or who did not bother to apply the same high standards to CAL that The Open University has come to expect of correspondance texts, T.V., A.V., etc. At one level, more and better documentation is required for both tutors and students. For instance, tutors obviously need to know the 'answers' where appropriate and also should know something about the models used to generate the data which their students are asked to interpret. This documentation must be supplied in reasonable time. At another level, it is unreasonable to expect tutors, employed for their ability to teach an academic subject, to engage in what is still a relatively novel teaching exercise without more support from the course team or training in CAL if they so desire. At the most mundane level this must include procedures for 'logging-in' to the various Open University computers and

what to do if things go wrong.

There was a general acceptance that getting hold of the programs in order to run them was a 'chancey' business and the whole process was shrouded in a certain degree of mystery. This is rubbish! Most failures to 'log-in' to the computer system are due to human error, probably aggravated by insecurity generated by inadequate educational support and documentation. However, unambiguous, easy to follow and thoroughly tested instructions posted by each terminal should help enormously. In any case facilities such as auto-dialling and ACS's new DECwriters are making many traditional bug-bears things of the past. Course teams should concern themselves solely with the education and with giving course-specific information (e.g. passwords) and leave ACS to up-date posters, leaflets, etc dealing with how to actually use the computing equipment, so that they keep pace with changing technology. At least then, a range of slightly different instructions will not be presented to tutors and students.

Most importantly, everybody concerned should accept simuation CAL (and indeed other types of CAL) as an educational tool and nothing more. It is therefore not something to be frightened of, nor is it something which should be elevated onto some sort of a pedestal. It is a tool or a medium, like T.V. or A.V. What matters is the material presented through that medium, and the context in

which it is set. Each program should be critically assessed by course teams and tutors. If found lacking, a program should not be used. If, on the other hand, it is thought to be useful then every effort should be made to see that it is used properly.

6.0 RECOMMENDATIONS

1. Since simulation CAL can be very successful, the Science Faculty should use it more extensively where appropriate and, in particular, gain experience in its use in distance learning per se.

2. The Faculty should recognise that simulation CAL requires as much thought and effort devoted to its use as any other aspect of it teaching.

3. Course teams should supply good documentation and/or training for both students and tutorial staff.

4. Course teams should be prepared to incorporate the experience and good ideas of students and tutorial staff in regular revision of the documentation.

5. Since successful use of simulation CAL seems to depend on thorough integration of simulation CAL with the rest of the educational 'package', course teams should give particular attention to the 'how' and the 'why' of the

technique in relation to other aspects of their course.

6. Course teams should leave the writing of posters, leaflets, etc about the technical aspects of 'logging-in' to and using computer equipment to ACS so that such information is kept up to date by the people who actually install new types of terminal, etc. At the same time, course teams should check that ACS facilities and documentation remains appropriate to the educational needs of the Faculty and insist on improvements when necessary.

COMPUTER-ASSISTED LEARNING RESEARCH GROUP

List of Technical Reports

These reports may be obtained from:-

Ann Jones, Institute of Educational Technology, The Open University, Walton Hall, MILTON KEYNES, MK7 6AA, England.

Report No.	Title and Author
1	M.A. Bramer (1980) Using Computers in Distance Education: The first ten years of the British Open University.
3	M.A. Bramer (1980) COMAL-80 - Adding Structure to BASIC.
4	A. Jones (1980) An evaluation of the SOLO programming language: A pilot study of its use at summer school.
5	A. Jones, T. O'Shea (1981) An evaluation of tutorial CAL at the Open University: the use of Cicero in SDT286.
6	E.L. Whitelegg (1981) An evaluation of tutorial CAL at the Open University: the use of MERLIN in ST291.
7	M.W. Lewis (1980) Improving SOLO's User-Interface: An Empirical study of user behaviour and a proposal for cost-effective enhancements to SOLO.
8	A.T. Vincent (1980) Some applications of a microcomputer.
9	T. O'Shea A. Floyd (1981) Recording Children's Mathematical Behaviour.
10	A.T. Vincent (1981) Computer-assisted support for blind students: the use of a microcomputer-linked voice synthesizer.
11	P. Bacsich (1981) Viewdata-style delivery mechanisms for CAL.
12	P.J. Murphy (1981) Biological simulations in distance learning.
13	P.J. Murphy (1981) Computer simulation in Education: Genetics and Evolution.
14	I. Every (1981) Graphics and animation in teaching dialogues.
15	P.J. Murphy, E. Scanlon, E.L. Whitelegg (1981) An evaluation of simulation CAL in the Science Faculty during 1980.
16	M, Eisenstadt, J. Laubsch, J.H. Kahney (1981) Creating pleasant programming environments for cognitive science students.

Report No.	Title and Author
17	J. Laubsch, M. Eisenstadt (1981) Domain specific debugging aids for novice programmers.
18	J. Roberts (1981) Are fuzzy grids really necessary?
19	J. Preece (1981) Investigating how students interpret cartesian graphs.
20	E. Scanlon, Tom Vincent (1981) CAL in Science: Some Regional Implications.
21	A. Jones (1981) The representation of conceptual models: some issues.
22	E. Scanlon (1982) Improving Problem Solving in Physics.
23	M. Sharples (1982) CYCLOPS - A case study in the design of user-friendly educational technology.
24	T. Hasemer (1982) Mac SOLO.
25	A. Jones (1981) How do novices learn programming?
26	A.G. Priest (1981) A design for an Intelligent Mechanics Tutor.
27	A. Jones, and E. Scanlon; (Eds) A review of research in the CAL group: A report of the first annual conference, November 1981.
28	R. Evertz (1982) A production systems account of children's errors in fraction substraction.
29	A. Jones (1982) Mental models of a first programming language.
30	P. Smith, P.I. Zorkoczy (1982) RADIOTEXT.
31	P.J. Murphy (1982) Interactive Computer Tutorials in Open University Biology Courses.
32	A. Jones, and E. Scanlon (1983) Protocols and production systems.
33	J. Preece (1983) A study of pupils' graph concepts using an interactive computer program.
34	J. Preece (1983) Graph interpretation and sketching skills in 14 and 15 year olds.